MINIMIZING POWER LOSSES BY USING IMPROVED GENETIC ALGORITHM (IGA) FOR DISTRIBUTION NETWORK RECONFIGURATION (DNR)

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Bachelor of Industry Power Engineering
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SUPERVISOR ENDORSEMENT

"I hereby declare that I have read through this report entitle "Minimizing Power Losses by Using Improved Genetic Algorithm for Distribution Network Reconfiguration (DNR)" and found that it has comply the partial fulfillment for awarding the Degree of Bachelor of Electrical Engineering (Industrial Power)"

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2014

I declare that this report entitle “Minimizing Power Losses by Using Improved Genetic Algorithm (IGA) for Distribution Network Reconfiguration (DNR)” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidate of any other degree.

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Date: …….

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Bissmillahirrahmanirrahim,

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ABSTRACT

Power losses issues persevered over few decades in the high demand utilization of energy electricity in developing countries. Thus, the radial structure of distribution network configuration is extensively used in high populated areas to ensure continuity of power supply in the event of fault. This paper proposes heuristic Genetic Algorithm known as IGA (Improved Genetic Algorithm) in consideration of genetic operator probabilities likewise the progression of switch adjustment in Distribution Network Reconfiguration (DNR) while satisfying the parameters constraints. The IGA algorithm was embodied throughout the process in IEEE 33-bus distribution system in selection of five tie switches. As a consequence, the power losses were ranked in accordance to the minimum values and voltage profile improvement obtainable by the proposed algorithm. The results show that the IGA performs better than GA by giving the minimized value of power losses.

***Keywords** : Distribution Network Reconfiguration (DNR), Genetic Algorithm (GA), Improved Genetic Algorithm (IGA)*

ABSTRAK

Isu-isu kehilangan kuasa sepanjang beberapa dekad dalam permintaan penggunaan tenaga elektrik yang tinggi di negara-negara membangun. Oleh itu, struktur jejarian konfigurasi rangkaian pengagihan digunakan dengan meluas di kawasan yang berpenduduk tinggi untuk memastikan kesinambungan bekalan kuasa sekiranya ia gagal berfungsi. Kajian ini mencadangkan heuristik Algoritma Genetik sebagai balasan bagi kebarangkalian operator genetik begitu juga perkembangan suis pelarasan dalam Rangkaian Pengagihan Penyusunan (DNR) manakala memuaskan parameter kekangan. Algoritma ini diguna pakai sepanjang proses dalam IEEE 33 bas sistem pengagihan dalam pemilihan lima suis. Akibatnya, kerugian kuasa berjaya diminimumkan dan peningkatan profil voltan diperolehi oleh algoritma yang dicadangkan. Keputusan menunjukkan bahawa algoritma ini lebih baik daripada algoritma genetik yang biasa dengan mengurangkan kerugian kuasa.

Kata Kunci: Penyusunan Rangkaian Pengagihan (DNR), Algoritma Genetik (GA), Penambahbaikan Algoritma Genetik (IGA)

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CHAPTER 1

INTRODUCTION

1.0 Research Background

Power interruptions are the biggest obstacles to be tackled in the power distribution fields. They come in two types which are scheduled and unscheduled power interruption. Firstly, a scheduled power interruption that is normally conducted by the power utility company for maintenance purposes. Secondly, an occurrence of power failure namely as an unscheduled interruption that happens because of abrupt circumstances for example natural disaster like lightning strikes. Besides natural disaster, there are thousands other causes of power interruptions like low voltage of distribution level, load variations, overload, damage of equipment, damage caused by third party, loose of connection and even work quality [1].

Indeed, numerous researches have been done with the aim of reducing power losses in distribution system while maintaining its quality and reliability of the system itself. Many techniques have been approached such as Distributed Automation System (DAS) and Distribution Network Reconfiguration (DNR) [1-2]. This research attempts to use DNR which is a usable operation in reducing distribution feeder as well as improving the system security.

DNR technique consists of traditional network reconfiguration and heuristic reconstruction method. In order to solve DNR, there are few categories of approaches that can be applied which are switch exchange method, mathematical optimization theory, artificial intelligence algorithm and optimal flow pattern [3].Initially, the traditional network reconfiguration is implemented to reduce power losses, balance the load and stabilize voltage

in normal operating conditions where it does not include the impact of network reconfiguration to the system reliability.

There are many researches to reconfigure the distribution network are introduced such as the developing of algorithms like Particle Swarm optimization (PSO), Simulated Annealing (SA), Tabu Search (TS) and Genetic Algorithm (GA). Particle swarm optimization (PSO) algorithm proposed in [2-4] used population-based approach. Modification was done by linearly decrease the inertia weight during simulation. It is capable of finding optimal or near-optimal solution to the test system and it operating time is acceptable for practical applications.

In this paper [3], the authors attempt to use IGA to find the optimal small size subset of features from the original large feature set. It proposed a new modified GA based on enhanced diversity, parents selection and improved genetic operators. The DGA is done through a modified roulette wheel selection procedures to be able to introduce more diverse feature of GA members and to avoid the mating of exact members.

1.1 Problem Statement

Distribution system is the part that connects the load and supply. According to [4], all loads are connected to the transmission lines at substation by distribution system through voltage transformation and switching functions. Hence, distribution system has to be able to cater the loads efficiently. However, fault occurrence at distribution system is inevitable due to loads variation, ageing of transformer, low voltage level at distribution system and the line losses itself. When the fault occur, the distribution system seems to produce losses at a very large number and by definition as said in [1], power losses in distribution system is the difference between the energy generated and the energy sold to the customers . This means that the customer have the rights to obtain as much power as possible from the supply. Hence, reconfiguration is introduced in order to minimize these losses in distribution system and then improved its quality and reliability.

1.2 Objectives

This research is mainly aims on the following:

1. To analyze the performance of IEEE-33 bus distribution system by using Improved Genetic Algorithm (IGA) in MATLAB2013 software.

1.3 Scope

The test system is only on IEEE-33 buses, radial configuration distribution system of 132/11 kV and is being simulated in MATLAB2013 software. In this paper, only one method is used which is Improved Genetic Algorithm (IGA) without considerations of Distributed Generation, DG.

1.4 Chapter Outline

Chapter 1 covers the introduction of thesis. Chapter 2 describes the literature review which guides and evolves through this paper. Chapter 3 presents the IEEE-33 bus distribution system and also describes the methodology of IGA applied in this paper. Chapter 4 shows the results of a simulation to demonstrate the performance of the proposed algorithms and Section 5 contains conclusion of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The overall power system includes generation, transmission, distribution and loads. Distribution system is located at the end of the power systems which connect users and power system and then supply and distribute power to users. Thus, distribution system power capability and quality has to be fully maintained at its best operation. Referring to [1-4], the reconfiguration technique is done to maintain the radiality of the network and to cater all the loads by altering the on/off status of open/closed switch.

Several methods used to realize minimizing power losses such as traditional PSO, EPSO, GA and IGA. This research focuses on IGA, which is the improved version of GA. Genetic Algorithm, GA is a metaheuristic technique where it does not operate on a single point but operate the whole parameter code. Besides that, GA start searching not from a single point but from a group of points and the search is based on probabilistic change rules than uncertain rules. However, this conventional GA has slow convergence rate, local optimum and it ignores cooperation between populations. Thus, by using IGA which is simple, robust search algorithm and it gives good solution rapidly for difficult high-dimensional problem as mentioned in [1,2] actually helps to overcome the flaw of GA.

2.2 Distribution System in Malaysia

In Malaysia, power system has three main parts which have been mentioned earlier which are generation, transmission and distribution. Fig. 2.1 below shows a simple block diagram of a power system in Malaysia.

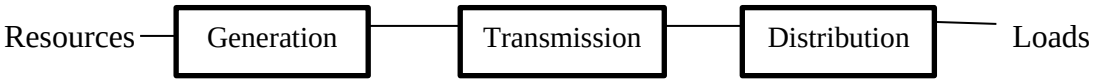

Fig. 2.1: Simple Block Diagram of Power System in Malaysia

The distribution networks have many types of configuration such as petal, mesh, loop and radial configuration. As mentioned in [2], radial configuration is most used distribution networks configuration in Malaysia with lowest initial cost and the only practical solution for rural network with long supply lines and low load densities due to economic reasons. Fig. 2.2 illustrates simple diagram of radial configuration. This type of configuration has such characteristics of supplying on one end only while the feeders are separated in radiated from a single substation to feed the distributors at one end only. However, this configuration has poor service reliability and security. It has no provision for feedback supply to affected customers downstream of the cable fault.

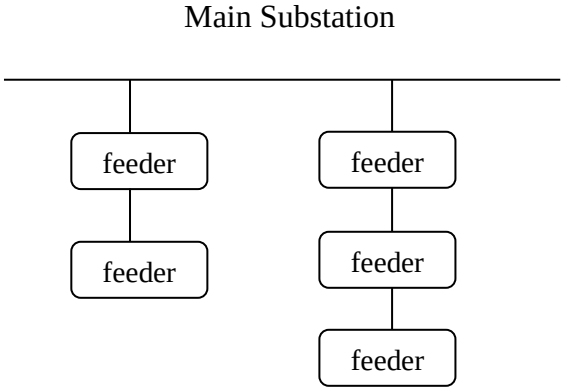

Fig. 2.2: Radial Configuration

Loop configuration, mesh configuration and petal configuration are being shown in Fig. 2.3, 2.4 and 2.5, respectively.

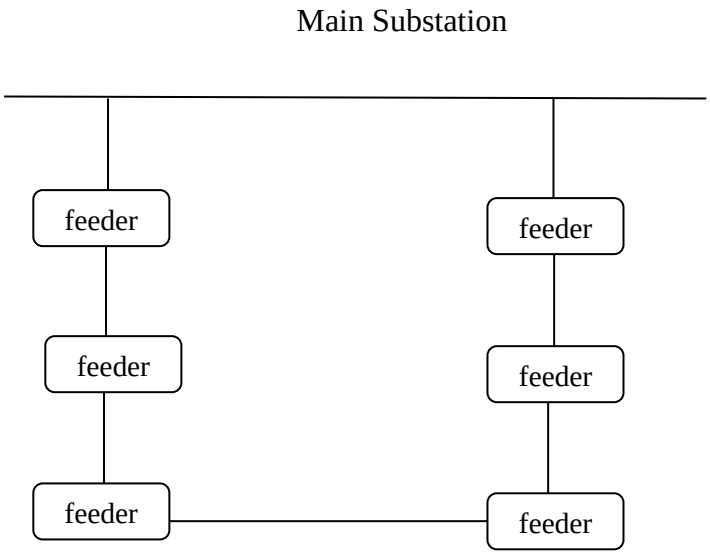

Fig. 2.3 : Loop Configuration

Fig. 2.3 illustrates loop configuration from the same source where several substations are connected from two cables and it ends on one main station. This configuration operated like two different radial configurations and somehow maintaining the uniform size of cable which will make this configuration to cater the network easily [2].

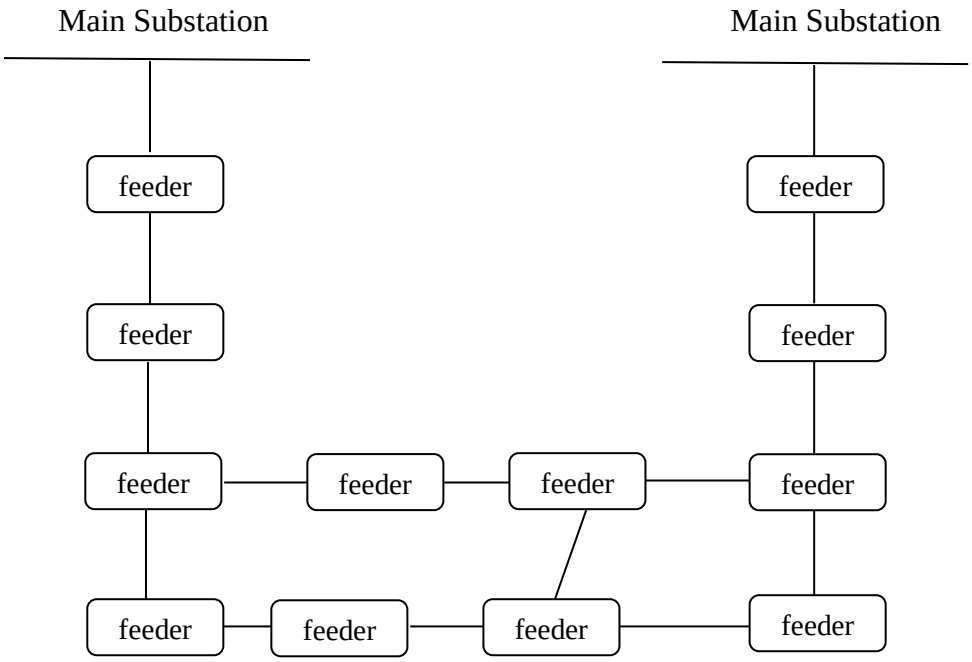

Fig. 2.4 : Mesh Configuration

A mesh configuration illustrated in Fig. 2.4 is the combination of several ring systems. In order to obtain increasing supply security, this configuration has to be an interconnecting circuit. This type of configuration has high network losses but somehow produces higher utilization of circuit capacity [2].

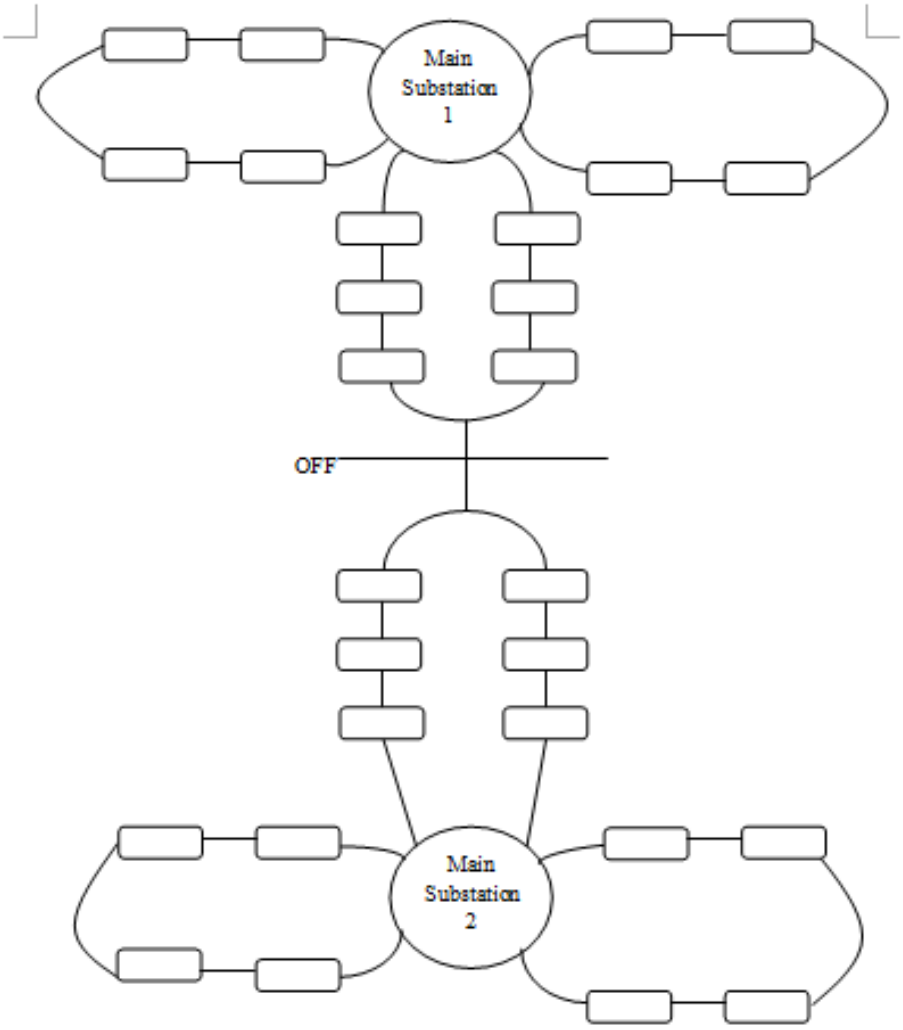

Fig. 2.5 : Petal Configuration

Fig. 2.5 is a petal configuration where it is the interconnection of two loop circuits from different main substations and this configuration can improve level of supply security and reliability [2].

2.3 Theory and Basic Principles

2.3.1 Distribution Network Reconfiguration (DNR)

Traditional network reconfiguration is implemented to reduce power losses, balance the load and stabilize voltage in normal operating conditions where it do not include the impact of network reconfiguration to the system reliability. John Holland are first to introduce the use of distribution system reconfiguration in minimizing power losses. In determining the minimum loss configurations, he use branch and bound type optimization techniques. While in 1989, there are other research done on balancing load and generating loss reduction that introduced an integer programming problem which was said to be the one of the efficient load flow equations.

The heuristic reconstruction method proposed requires closing the switches and separating the network into a small ring network. Then the network is opened each time till the networks is back to the radial structure and this process should reduce losses. Although initial state is not dependable in this method final reconstruction structure, the solution process still gives optimal or near optimal network structure. This method uses Direct Current (DC) calculation while ignoring voltage phase angle and network constraints. Actual distribution network consists of a large number of switches which increase the dimension and then may results in serious "combinatorial explosion" problem [3,4].

According to [4,5] there is also a single ring network optimization problem with only one pair of opened and closed switches which proposed by Ji-Yuan Fan. This method uses a nonlinear integer programming with a quadratic objective function and 0-1 state variables as its mathematical model. This method use shortest path method to easily formed tree network and finding the power supply path for each loads. Therefore, it is easily used for reconstruction optimization of complex network since it algorithm does not need any special requirements to network optimizing [6].

According to [7-9], Distribution Network Reconfiguration (DNR) has various numbers of normally open/closed switches and is usable and important operation in reducing losses of distribution feeder and improving security of the system. As the operating conditions change, optimal operation of distribution system can be realized by reconfiguring

the system to minimize losses. However, it is not easy to obtain fast and exact optimal solution in real system because this reconfiguration takes various operational constraints in large scales into account.

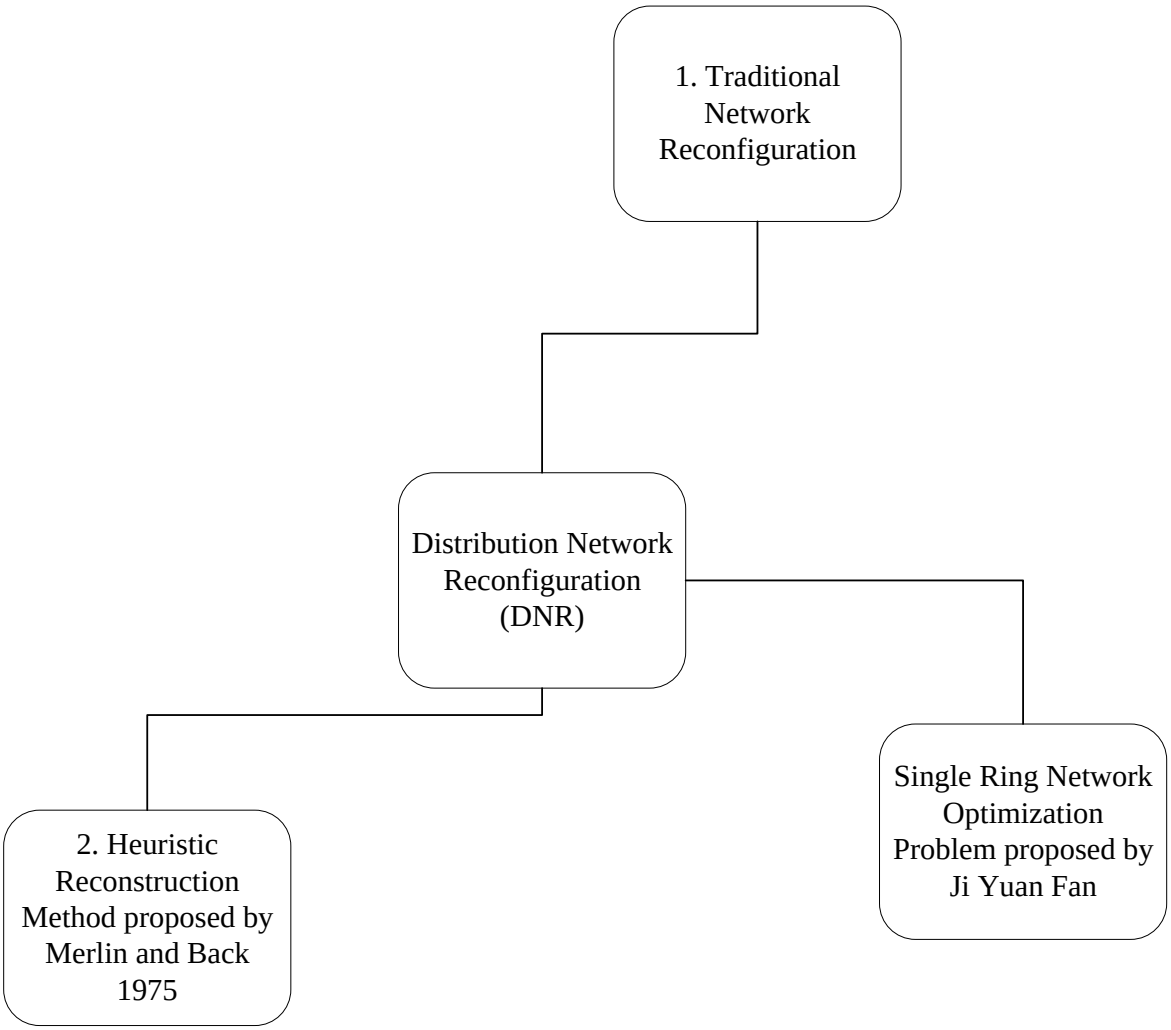

Fig. 2.6 : Evolution of Distribution Network Reconfiguration

2.3.2 Genetic Algorithm (GA)

Before enhancing to Improved Genetic Algorithm (IGA), the concept of GA has to be understood first. According to [8], Genetic Algorithm (GA) is a search technique used in computing to look for possible solution in search problems and optimization. This technique is inspired from evolutionary biology which is consists of inheritance, mutation, selection and crossover (recombination).

Fig. 2.7 below describes simple Genetic Algorithm [9]. Most likely solutions of traditional GA are represented in bit string (0-1) but other encoding can also be considered. GA first defines the chromosomes according to fitness function before going through selection according to *roulette wheel method*. The final stage of GA would be crossover and mutation before obtaining the best solution.

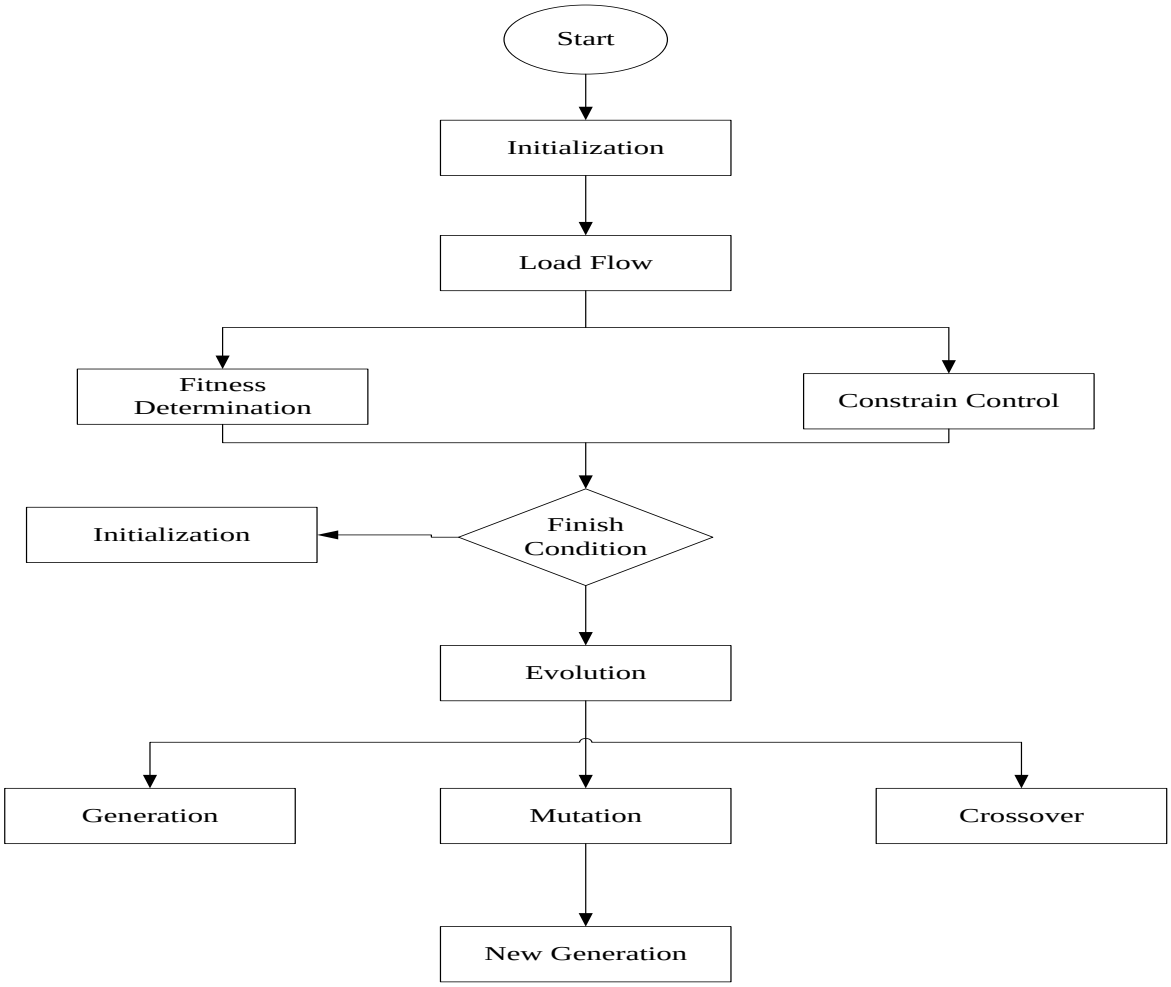

Fig. 2.7 : Flowchart of a Simple Genetic Algorithm [9]

Based on [5], Genetic Algorithm (GA) is inspired from evolutionary theory where its search method is based on natural genetic selection mechanism. GA results in optimization of parameters formed by encoded string groups where actually it introduced biological evolution theory of 'survival of the fittest'. By simulating the best survival of gene string and using the method of random information exchange, GA search for its optimization program. However, it became a flaw when GA performance was affected as a result of constant crossover and mutation rates.

Characteristics of GA are simply said as GA operates the code of the parameter itself, GA start searching from a group of points rather than one point and finally GA search is based on the rules of probabilistic change rather than not uncertain rule. Nevertheless, GA provides the following advantages. Firstly, it produces high possibility of obtaining optimal values in early generations and it has high convergence. Besides that, GA is able to handle sick and discrete optimization problem and also GA has inherent characteristics of parallel computing.

David E. Goldberg in his book [10] defines GA as a search algorithm based on mechanics of natural selection and genetics. GA forms its search algorithm from combined survival of the fittest among string structures with structured and randomized information exchange. In additional, GA efficiently venture historical information to consider new search points with expected improved performance. GA requires natural parameter set of optimization problems to be coded as finite-length strings over some finite alphabet.

A simple GA is actually very simple where it just copy strings and then swap partial strings where it has been composed to three operators which are reproduction, crossover and mutation. This GA is different from the conventional optimization techniques where it involves direct manipulation of a coding and its search from a population, not from a single point. Besides that, GA search through sampling not by a blind search and it uses stochastic operators instead of deterministic rules.

While in [11], Tom V. Matthew defines GA as the search algorithm that is based on the concepts of both natural selection and genetics. The first objective of developing GA is to simulate some processes in natural evolution where it operates on chromosomes (organic device) to encode the structure of living being. Fig. 2.8 below describes the working principle of a simple GA.

```
/* Algorithm GA */
formulate initial population
randomly initialize population
repeat
evaluate objective function
        find fitness function
        apply genetic operators
                reproduction
                crossover
                mutation
until   stopping criteria
```

Fig. 2.8: Working Principle of Simple GA [11]

In GA, the problem is simply described by the coding of variables where the common variable used is a binary string or a vector. However, GA is in its best operations when solution vectors are in binary string. Table 2.1 shows description of GA processes mentioned earlier.

Table 2.1 : Description of GA Processes

GA process	Description
Fitness Function	Derivation of the objective functions and applied to the successive genetic operations. Biological terms define fitness as a measure of the chromosomes reproductive efficiency. From fitness function, chromosomes with high fitness value are selected for the next stage.
Reproduction	The operator that copy better strings in new population. Good strings in the population are being selected before forming mating pool. It is necessary to maintain reproduction in current population so that next population is better produced. Most common used operator in reproduction is *Roulette-Wheel Selection.* These methods choose population with higher fitness for the mating pool.